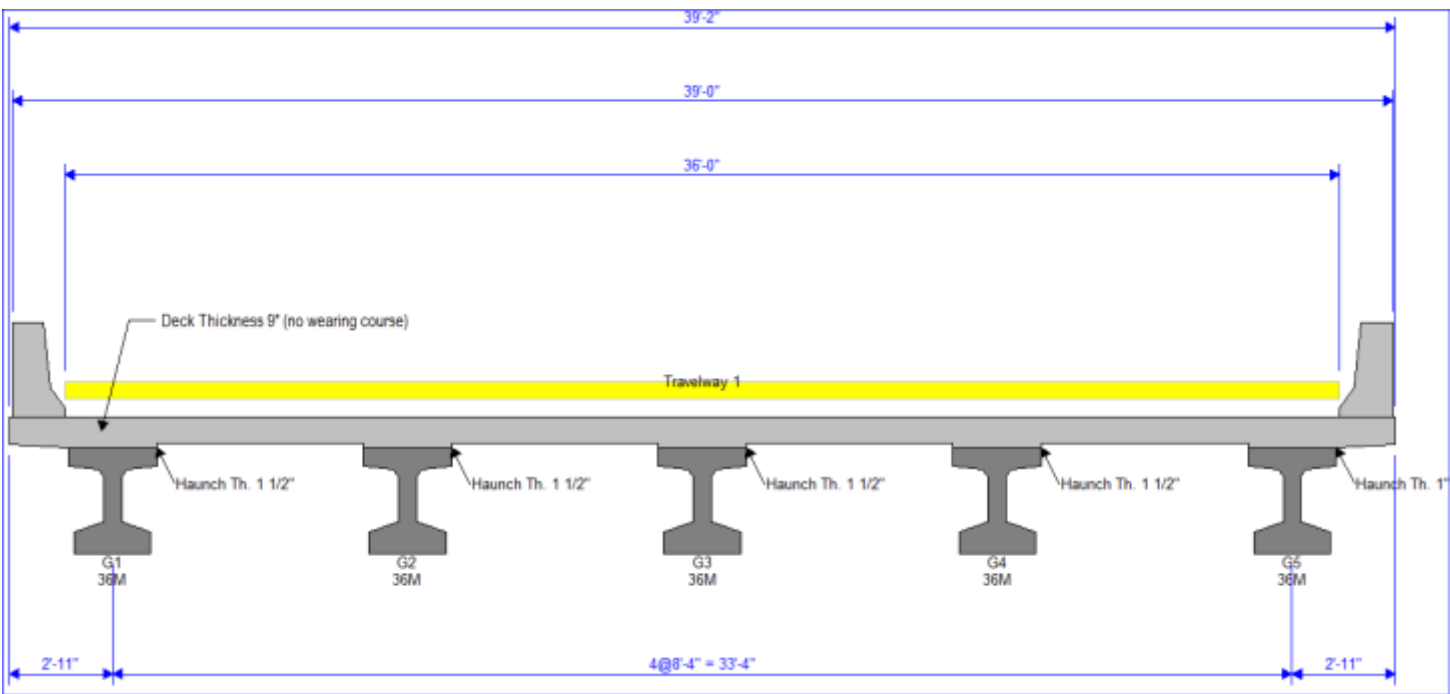
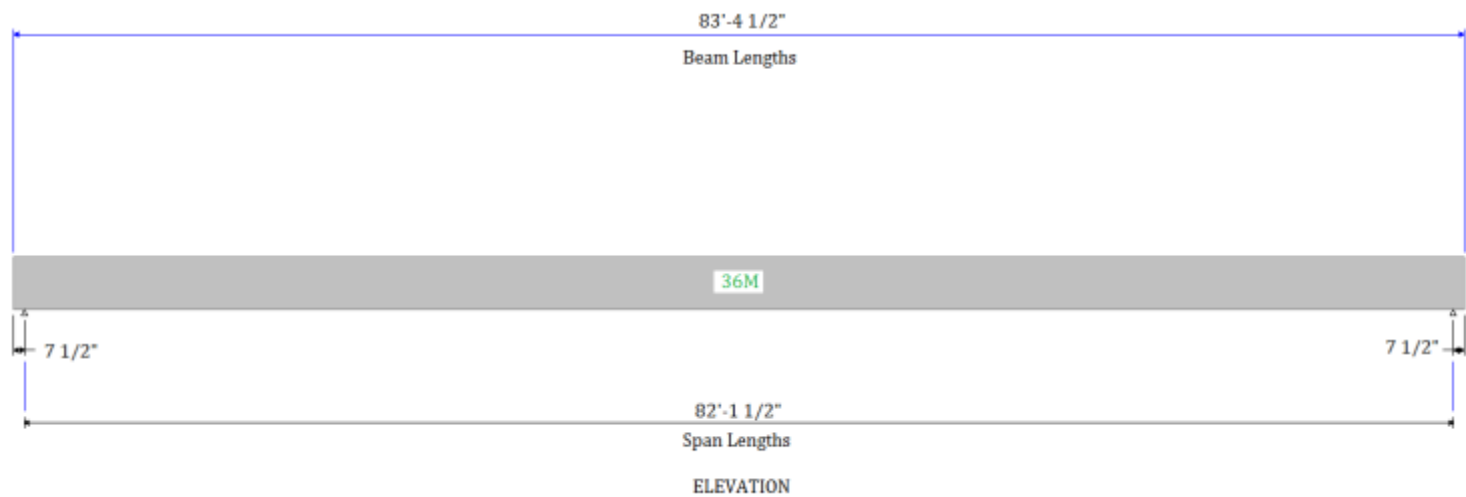


AASHTOWare BrR - SIMPLE SPAN PRESTRESSED I BEAM EXAMPLE - BR 76015



PS1 - Simple Span Prestressed I Beam Example (BrR 6.7.1)

1. From the Bridge Explorer create a new bridge and enter the following description data:
 - a. Bridge ID – Enter Bridge number (usually 5 digits). For bridges with only 3 or 4 digits, enter space(s) then enter the bridge number, e.g., __123, _1234
 - b. NBI Structure ID – Same as Bridge ID
 - c. Bridge Completely Define – Check this box to indicate whether or not the bridge superstructure (members and spans) is completely defined in this BrR file.
 - d. Name – Enter the three digit bridge type. (see Bridge LRFD Design Manual, Appendix 2-A). If there is more than one type in the bridge, enter the type of the main span (or lowest rated ?) and add suffix, m (for multiple).
 - e. Year Built – Year of construction
 - f. Description – select those that apply from list below, add others if needed
 - This Bridge was copied from its' twin, Br xxxxx
 - Twin to Br xxxxx
 - Number of spans
 - Other bridge types if multiple types in one bridge
 - Note if different ratings apply to each side of bridge or direction of traffic or if bridge has one way traffic
 - Flare or curve, note if present
 - Skew angle
 - Describe dead load distribution: Sidewalks, medians, rails, etc.
 - Describe in detail if for any reason the computer model deviates from the plan
 - Does / does not have end blocks, (For prestressed beam bridges)
 - Replaces Bridge xxxx
 - Initials of person rating and date completed
 - g. Location – City or Township name
 - h. Length – XXXX feet
 - i. Facility Carried – Facility carried over the bridge. Use the highway abbreviation without periods. If the bridge carries one way traffic, add this as a suffix. Examples: I 94, I 35 SB, US 12, US 2 WB, MN 36, CSAH 44, CR 88. If no highway number exists, use the street name/number, etc.
 - j. Route number - Often the same as Facility carried. If a minor road crosses over a major highway, enter the major highway number. May be a second highway no. over/under. Omit Prefixes (I, US, MN, CSAH, etc.)
 - k. Feature intersected - Highway, river, stream or feature under the bridge.
 - l. Mile post – Leave blank
 - m. Units – English preferred

76015

Bridge ID: 76015 NBI Structure ID (8): 76015 ☐ Template ☒ Superstructures
☒ Bridge Completely Defined ☐ Culverts

Description Description (cont'd) Alternatives Global Reference Point Traffic Custom Agency Fields

Name: 501 Year Built: 2014

Description: 1-span 36M PCB, no skew, 36' roadway, 2-Concrete Barrier
Integral abutments
YG 3/17/2014

Location: Cashel Township Length: 84.30 ft

Facility Carried (7): TH 29 Route Number: 29

Feat. Intersected (6): Ditch Mi. Post:

Default Units: US Customary

AASHTOWare Association... ☒ BrR ☒ BrD ☐ BrM

OK Apply Cancel

2. Enter the following description (cont'd)...

- a. District – Select from pull-down menu
- b. County – Select from pull-down menu
- c. Owner – Select from pull-down menu
- d. Maintainer – Select from pull-down menu (usually the same as owner)
- e. Administrative Area – Select from pull down menu
- f. NHS Indicator – Leave blank
- g. Functional Class – Leave blank

76015

Bridge ID: 76015 NBI Structure ID (8): 76015 ☐ Template ☒ Superstructures
☒ Bridge Completely Defined ☐ Culverts

Description Description (cont'd) Alternatives Global Reference Point Traffic Custom Agency Fields

District (2): D4 - Detroit Lakes

County: Swift

Owner (22): State Highway Agency

Maintainer: State Highway Agency

Admin. Area: Being Rated by YG

NHS Indicator:

Functional Class:

AASHTOWare Association... ☒ BrR ☒ BrD ☐ BrM

OK Apply Cancel

3. Enter the following Traffic information:

- a. Recent ADTT - Enter the current truck traffic volume. This is called HCADT on the MnDOT Structure Inventory Report. If the HCADT is blank on the Inventory Report, use 12 % of the ADT.

Bridge ID: 76015 NBI Structure ID (8): 76015

☐ Template ☒ Bridge Completely Defined ☒ Superstructures ☐ Culverts

Description Description (cont'd) Alternatives Global Reference Point Traffic Custom Agency Fields

Truck PCT: %

ADT:

Directional PCT: %

Recent ADTT: 165

Design ADTT:

Est. annual traffic growth rate: %


Fatigue importance factor: Main Arterial, Interstate, Other

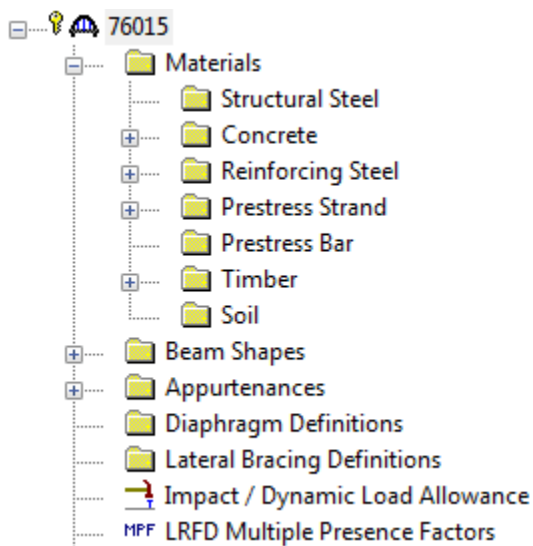
☐ Importance factor override

AASHTOWare Association... ☒ BrR ☒ BrD ☐ BrM

OK Apply Cancel

Close the window by clicking OK. This saves the data to memory and closes the window.

4. To enter the materials to be used by members of the bridge, click on the  to expand the tree for Materials. The tree with the expanded Materials branch is shown below:



- a. To add a new concrete material for the beam, click on Concrete in the tree and select File/New from the menu (or double click on Concrete). The window shown below will open.

Bridge Materials - Concrete

Name: Description:

Compressive strength at 28 days (f'_c) = ksi

Initial compressive strength (f_{ci}) = ksi

Coefficient of thermal expansion = 1/F

Density (for dead loads) = kcf

Density (for modulus of elasticity) = kcf

Std Modulus of elasticity (E_c) = ksi

LRFD Modulus of elasticity (E_c) = ksi

Std Initial modulus of elasticity = ksi

LRFD Initial modulus of elasticity = ksi

Poisson's ratio =

Composition of concrete =

Modulus of rupture = ksi

Shear factor =

Copy To Library... Copy from Library... OK Apply Cancel

- b. Add the concrete material "PS 9.0 ksi" by copying the closest concrete material properties from the Library and modifying the values to match the concrete properties of the beam. See window below.

Library Data: Materials - Concrete

Name	Description	Library	Units	f'_c	f_{ci}	α	DL Density	Modulus Density	Std Modulus of	LRFD Modulus of	Poisson's Ratio
PS 8.2 ksi	$f_{ci} = 7.2$ ksi	Agency	US Cus	8.200	7.200	0.0000	0.155	0.145	4622.41	4622.41	0.200
PS 8.3 ksi	$f_{ci} = 7.3$ ksi	Agency	US Cus	8.300	7.300	0.0000	0.155	0.145	4644.43	4644.43	0.200
PS 8.4 ksi	$f_{ci} = 7.4$ ksi	Agency	US Cus	8.400	7.400	0.0000	0.155	0.145	4666.32	4666.32	0.200
PS 8.5 ksi	$f_{ci} = 7.5$ ksi	Agency	US Cus	8.500	7.500	0.0000	0.155	0.145	4688.08	4688.08	0.200
PS 8.6 ksi	$f_{ci} = 7.6$ ksi	Agency	US Cus	8.600	7.600	0.0000	0.155	0.145	4709.71	4709.71	0.200
PS 8.7 ksi	$f_{ci} = 7.7$ ksi	Agency	US Cus	8.700	7.700	0.0000	0.155	0.145	4731.21	4731.21	0.200
PS 8.8 ksi	$f_{ci} = 7.8$ ksi	Agency	US Cus	8.800	7.800	0.0000	0.155	0.145	4752.60	4752.60	0.200
PS 8.9 ksi	$f_{ci} = 7.9$ ksi	Agency	US Cus	8.900	7.900	0.0000	0.155	0.145	4773.86	4773.86	0.200
PS 9.0 ksi	$f_{ci} = 8.0$ ksi	Agency	US Cus	9.000	8.000	0.0000	0.155	0.145	4795.00	4795.00	0.200
Std 3.0 ksi	Pre 1960	Agency	US Cus	3.000		0.0000	0.150	0.145	3320.56	3320.56	0.200

OK Apply Cancel

Note: AASHTOWare BrR only computes modulus of elasticity using AASHTO LRFD Equation 5.4.2.4-1. For $f'_c > 6$ ksi, MnDOT uses ACI 363 equation.

MnDOT Design Policy Item:

For pretensioned beams (M, MN, MW, and RB) fabricated with highstrength concrete (greater than 6.0 ksi), compute the modulus of elasticity with the ACI 363 equation below:

$$E_c = 1265 * \sqrt{f'_c} + 1000 \quad (\text{where } f'_c \text{ and } E_c \text{ are in ksi})$$

For all other pretensioned and post-tensioned elements, compute the modulus of elasticity using AASHTO LRFD Equation 5.4.2.4-1, with $K_1 = 1$ and $w_c = 0.150$ kcf.

$$E_c = 33,000 * K_1 * w_c^{1.5} * \sqrt{f'_c}$$

- c. Enter appropriate name and description and modify the concrete section property values. See window below:

Bridge Materials - Concrete

Name: PS 9.0 ksi Description: f'ci = 7.5 ksi

Compressive strength at 28 days (f'c) = 9.000 ksi

Initial compressive strength (f'ci) = 7.500 ksi

Coefficient of thermal expansion = 0.0000060000 1/F

Density (for dead loads) = 0.155 kcf

Density (for modulus of elasticity) = 0.145 kcf

Std Modulus of elasticity (Ec) = 4795.00 ksi

LRFD Modulus of elasticity (Ec) = 4795.00 ksi

Std Initial modulus of elasticity = 4465.35 ksi

LRFD Initial modulus of elasticity = 4465.35 ksi

Poisson's ratio = 0.200

Composition of concrete = Normal

Modulus of rupture = 0.720 ksi

Shear factor = 1.000

Since $f'_c > 6\text{ksi}$, these values were modified per MnDOT design policy

Copy To Library... Copy from Library... OK Apply Cancel

Click OK to save the data to memory and close the window.

- d. Add a concrete material for the deck, reinforcement material and prestress strand using the same techniques by copying from the library. Verify values for accuracy. The windows will look like shown below:

Bridge Materials - Concrete

Name: Class C (US) Description: Class C cement concrete

Compressive strength at 28 days (f'c) = 4.000 ksi

Initial compressive strength (f'ci) = ksi

Coefficient of thermal expansion = 0.0000060000 1/F

Density (for dead loads) = 0.150 kcf

Density (for modulus of elasticity) = 0.145 kcf

Std Modulus of elasticity (Ec) = 3644.15 ksi

LRFD Modulus of elasticity (Ec) = 3644.15 ksi

Std Initial modulus of elasticity = ksi

LRFD Initial modulus of elasticity = ksi

Poisson's ratio = 0.200

Composition of concrete = Normal

Modulus of rupture = 0.480 ksi

Shear factor = 1.000

Copy To Library... Copy from Library... OK Apply Cancel

Bridge Materials - Reinforcing Steel

Name: Grade 60 Description: 60 ksi reinforcing steel

Material Properties

Specified yield strength (Fy) = 60.000 ksi

Modulus of elasticity (Es) = 29000.00 ksi

Ultimate strength (Fu) = 90.000 ksi

Type

☐ Plain

☒ Epoxy

☐ Galvanized

☐ Other

Select Epoxy type reinforcing steel

Copy To Library... Copy from Library... OK Apply Cancel

Bridge Materials - PS Strand

Name: 0.6" (7W-270) LR Description: Low relaxation 0.600"/Seven Wire/fpu = 270

Strand diameter = 0.6000 in

Strand area = 0.217 in²

Strand type = Low Relaxation

Ultimate tensile strength (Fu) = 270.000 ksi

Yield strength (Fy) = 243.000 ksi

Modulus of elasticity (E) = 28500.00 ksi

Transfer length (Std) = 30.0000 in

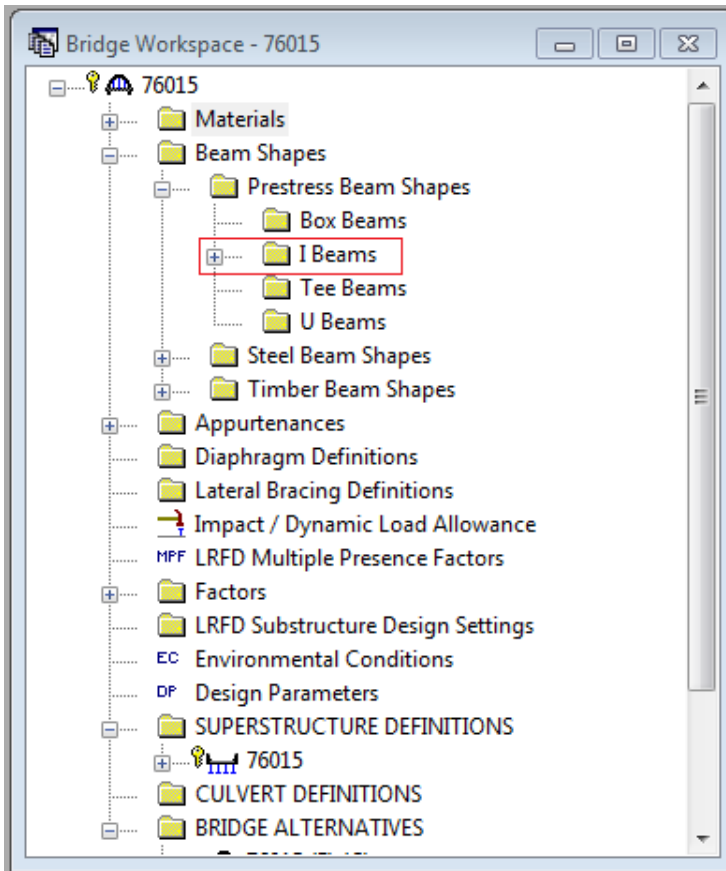
Transfer length (LRFD) = 36.0000 in

Unit load per length = 0.740 lb/ft

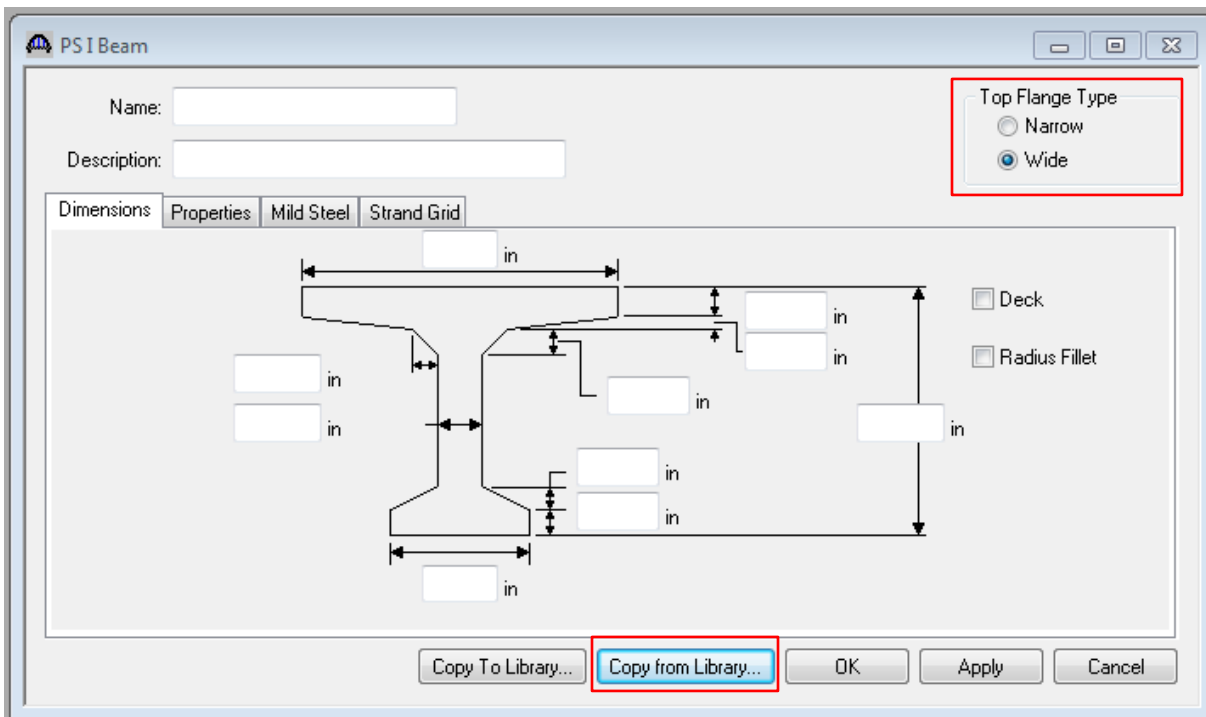
☐ Epoxy coated

Copy To Library... Copy from Library... OK Apply Cancel

- To enter a prestress beam shape to be used in this bridge, expand the tree labeled Beam Shapes as shown below:



- a. Click on I Beams in the tree and select File/New from the menu (or double click on I Beams in the tree). The window shown below will open.



- b. Select the Top Flange Type as "Wide" and click on the copy from Library button. Select 36M and click OK.

Bridge Appurtenances - Parapet

Name: Type F (18) without overlay

Description: Width = 18 inch; Approx 2000 -----

All dimensions are in inches

Additional Load = 0.025 kip/ft

2.5000

10.5000

5.0000

Reference Line

0.0000

22.0000

7.0000

3.0000

Back

Front

Roadway Surface

Parapet unit load = 0.1500 kcf

Calculated Properties

Net centroid (from reference line) = 6.424 in

Total load = 0.464 kip/ft

Copy from Library... OK Apply Cancel

7. If applicable, raised median can be entered on median tab, expand the tree branch labeled Median. To enter information, follow step 6.
8. The default Standard impact factors will be used.
9. To enter LRFR factors, expand the tree branch labeled Factors. Double click on LRFR in the tree to open the Factors window.

Bridge Workspace - 76015

76015

- Materials
- Beam Shapes
- Appurtenances
- Diaphragm Definitions
- Lateral Bracing Definitions
- Impact / Dynamic Load Allowance
- MFF LRFD Multiple Presence Factors
- Factors
 - LFD
 - LRFD
 - LRFR
- LRFD Substructure Design Settings
- EC Environmental Conditions
- DP Design Parameters
- SUPERSTRUCTURE DEFINITIONS
- 76015
- CULVERT DEFINITIONS
- BRIDGE ALTERNATIVES

- a. Click on "Copy from Library" button as shown below. This will open the window for Factors library data.

Factors - LRFR

Name:

Description:

Routine Permit Input
☐ Permit weight
☒ Permit weight ratio

Load Factors: Legal Loads Permit Loads Concrete Steel Wood Specifications

Bridge Type: Steel

Limit State	Dead Load		Design Load		Legal L		Permit		Vehicle				
	DC	DW	Invento	Operat	LL	LL	Inv	Op	Consider		Legal	Permit	
									LL	LL			
STRENGTH													
STRENGTH													
SERVICE II													
FATIGUE													

Copy from Library... OK Apply Cancel

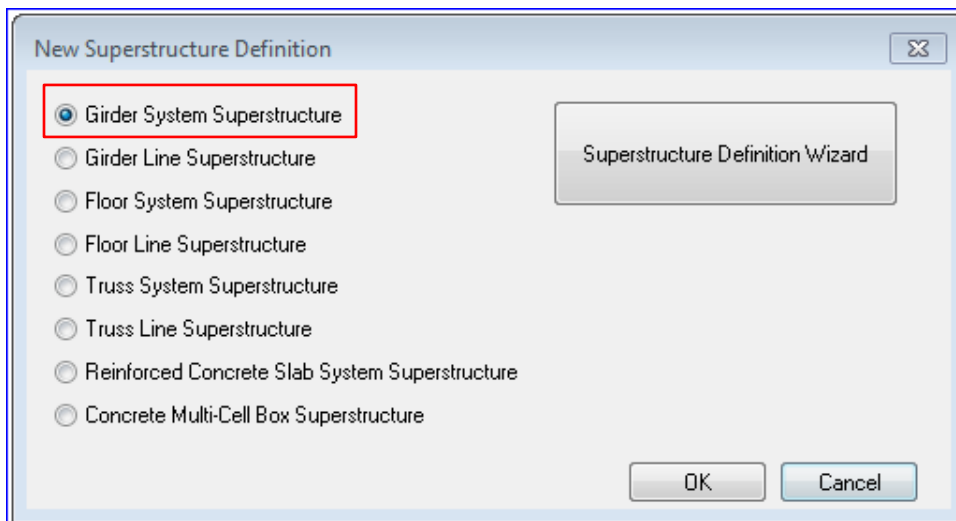
- b. Select the most current AASHTO Specifications, "AASHTO Spec, 2011 (2015 Interim) AASHTO LRFR Spec." as shown below. Click OK to save the data to memory and close the window.

Library Data: Factors - LRFR

Name	Description	Library
2003 AASHTO LRFR Specifications	2003 AASHTO LRFR Specifications, including 2005 Interims	Standard
2008 AASHTO LRFR Specifications	2008 AASHTO LRFR Specifications, including 2010 Interims	Standard
2011 (2013 Interim) AASHTO LRFR Spec.	AASHTO Manual for Bridge Evaluation, 2nd Edition, including 2013 interims.	Standard
2011 (2014 Interim) AASHTO LRFR Spec.	AASHTO Manual for Bridge Evaluation, 2nd Edition, including 2014 interims.	Standard
2011 (2015 Interim) AASHTO LRFR Spec.	AASHTO Manual for Bridge Evaluation, 2nd Edition, including 2015 interims.	Standard
2011 AASHTO LRFR Specifications	2011 AASHTO LRFR Specifications	Standard
2013 Interims AASHTO LRFR Culvert Spec.	Includes only the culvert factors as approved by the T-18 committee	Standard

OK Apply Cancel

10. To create the superstructure type for the bridge, double click on SUPERSTRUCTURE DEFINITIONS (or click on SUPERSTRUCTURE DEFINITIONS and select File/New from the menu or right mouse click on SUPERSTRUCTURE DEFINITIONS and select New from the popup menu) to create a new structure definition. The following dialog will open.



- a. Select Girder System and click OK and the Structure Definition window will open. Enter the appropriate data as shown below and check P/S box (for PCB). Click on OK to save the data to memory and close the window.

Definition Analysis Specs Engine

Name: 76015

Description:

Default Units: US Customary

Number of spans: 1

Number of girders: 5

Enter Span Lengths Along the Reference Line:

Span	Length (ft)
1	82.13

Frame Structure Simplified Definition

Deck type: Concrete

For PS only

Average humidity: 72.000 %

Member Alt. Types

☐ Steel

☒ P/S

☐ R/C

☐ Timber

Horizontal Curvature Along Reference Line

☐ Horizontal curvature

Distance from PC to first support line: ft

Start tangent length: ft

Radius: ft

Direction: Left

End tangent length: ft

Distance from last support line to PT: ft

Design speed: mph

Superelevation: %

Superstructure Alignment

☒ Curved

☐ Tangent, curved, tangent

☐ Tangent, curved

☐ Curved, tangent

OK Apply Cancel

11. Click Load Case Description to define the dead load cases. The composite Dead Load (DL2) needs to be separated into two (or more) items (lines). This is because LRFR will use different load factors for each of the items.

-D, DC includes the original wearing course, railings, median, sidewalk, etc...

-D, DW includes utilities.

Enter the required information and click the OK button. The completed Load Case Description window is shown below.

Load Case Name	Description	Stage	Type	Time* (Days)
DC1	DC acting on non-composite section	Non-composite (Stage 1)	D,DC	
DC2	DC acting on long-term composite section	Composite (long term) (Stage 2)	D,DC	
DW	DW acting on long-term composite section	Composite (long term) (Stage 2)	D,DW	
Utility	Utility	Composite (long term) (Stage 2)	D,DC	
Diaphragm	Diaphragm weight	Non-composite (Stage 1)	D,DC	

*Prestressed members only

Add Default Load Case Descriptions

New Duplicate Delete

OK Apply Cancel

12. Double-click on Framing Plan Detail to describe the framing plan. Enter the appropriate data as shown below.

Number of spans = 1 Number of girders = 5

Layout Diaphragms

Girder Spacing Orientation

☒ Perpendicular to girder

☐ Along support

Support	Skew (Degrees)
1	0.0000
2	0.0000

Girder Bay	Girder Spacing (ft)	
	Start of Girder	End of Girder
1	8.33	8.33
2	8.33	8.33
3	8.33	8.33
4	8.33	8.33

OK Apply Cancel

- Switch to the Diaphragms tab to enter diaphragm spacing. Click New and enter the following diaphragm information in the dialog shown below. Click on Copy Bay To button to copy diaphragm bracing information from Girder Bay 1 to other bays.

Note: Another option for entering diaphragm load is in the tree branch labeled MEMBERS. For each girder that is created, a point load can be entered in the Concentrated tab in the Member Loads element. See step 19

Structure Framing Plan Details

Number of spans = 1 Number of girders = 5

Layout Diaphragms

Girder Bay: 1 Copy Bay To... Diaphragm Wizard...

Support Number	Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Load (kip)	Diaphragm
	Left Girder	Right Girder				Left Girder	Right Girder		
1	0.00	0.00	41.06	1	41.06	41.06	41.06	0.2000	-- Not Assigned --

New Duplicate Delete

OK Apply Cancel

b. Select OK to close the window

- Next define the structure typical section by double-clicking on Structure Typical Section in the Bridge Workspace tree. If applicable, User can enter typical section information related to the deck, parapets, median, railings, generic barrier, sidewalk, lane position, and wearing surface. Input the data describing the typical section as shown below.

Basic deck geometry:

Structure Typical Section

Deck Deck (Cont'd) Parapet Median Railing Generic Sidewalk Lane Position Striped Lanes Wearing Surface

Superstructure definition reference line is within the bridge deck.

Distance from left edge of deck to superstructure definition reference line = Start 19.58 ft End 19.58 ft

Distance from right edge of deck to superstructure definition reference line = 19.58 ft 19.58 ft

Left overhang = 2.92 ft 2.92 ft

Computed right overhang = 2.92 ft 2.92 ft

OK Apply Cancel

- a. The Deck (cont'd) tab is used to enter information about the deck concrete and thickness. Enter total deck thickness as indicated in the plan (no deduction for wearing surface).

Structure Typical Section

Distance from left edge of deck to superstructure definition ref. line

Distance from right edge of deck to superstructure definition ref. line

Deck thickness

Superstructure Definition Reference Line

Left overhang

Right overhang

Deck Deck (Cont'd) Parapet Median Railing Generic Sidewalk Lane Position Striped Lanes Wearing Surface

Deck concrete: Class C (US)

Total deck thickness: 9.0000 in

Load case: Engine Assigned

Deck crack control parameter: kip/in

Sustained modular ratio factor: 3.000

Deck exposure factor:

OK Apply Cancel

Parapets:

14. Add two parapets as shown below.

Structure Typical Section

Back Front

Deck Deck (Cont'd) Parapet Median Railing Generic Sidewalk Lane Position Striped Lanes Wearing Surface

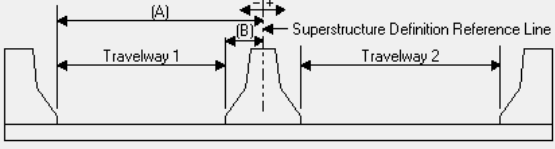
Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
Type F (18) without overlay	DC2	Back	Left Edge	0.08	0.08	Right
Type F (18) without overlay	DC2	Back	Right Edge	0.08	0.08	Left

New Duplicate Delete

OK Apply Cancel

Lane Positions:

15. Select the Lane Position tab and use the Compute... button to compute the lane positions. A dialog showing the results of the computation opens. Click Apply to apply the computed values. The Lane Position tab is populated as shown below.



Travelway Number	Distance From Left Edge of Travelway to Superstructure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Superstructure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Superstructure Definition Reference Line At End (A) (ft)	Distance From Right Edge of Travelway to Superstructure Definition Reference Line At End (B) (ft)
1	-18.00	18.00	-18.00	18.00

LRFD Fatigue
Lanes available to trucks:

☐ Override Truck fraction:

Compute... New Duplicate Delete

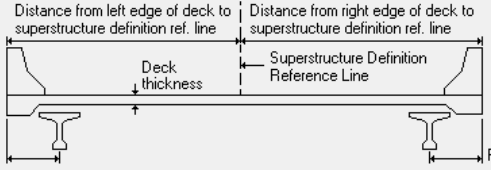
OK Apply Cancel

Striped Lanes:

16. Ignore this tab

Wearing Surface:

17. Since the plan calls for no wearing surface, it is not required that this tab is filled out. To show how a User would complete the section, data were entered as shown below.



Deck	Deck (Cont'd)	Parapet	Median	Railing	Generic	Sidewalk	Lane Position	Striped Lanes	Wearing Surface
<p>Wearing surface material: Concrete Overlay</p> <p>Description: Concrete Overlay</p> <p>Wearing surface thickness = 2.0000 in <input type="checkbox"/> Thickness field measured (D/W = 1.25 if checked)</p> <p>Wearing surface density = 150.000 pcf</p> <p>Load case: D/W</p> <p>Copy from Library...</p>									

OK Apply Cancel

a. Click OK to save the data to memory and close the window.

18. Now define a Stress Limit. A Stress Limit defines the allowable concrete stresses for a given concrete material. Double click on the Stress Limits tree item to open the window. Select the “PS 9.0 ksi” concrete material. Default values for the allowable stresses will be computed based on this concrete and the AASHTO Specifications. A default value for the final allowable slab compression is not computed since the deck concrete is typically different from the concrete used in the beam. Click OK to save this information to memory and close the window.

Stress Limit Sets - Concrete

Name: 9ksi Concrete Stress Limit

Description: fc=9ksi

Concrete Material: PS 9.0 ksi

	LFD	LRFD
Initial allowable compression:	4.500 ksi	4.500 ksi
Initial allowable tension:	0.200 ksi	0.200 ksi
Final allowable compression:	5.400 ksi	5.400 ksi
Final allowable tension:	0.570 ksi	0.570 ksi
Final allowable DL compression:	3.600 ksi	4.050 ksi
Final allowable slab compression:		
Final allowable compression: (LL + 1/2[Pe + DL])	3.600 ksi	3.600 ksi

OK Apply Cancel

19. Double click on the Prestress Properties tree item to open a window in which to define the prestress properties for this structure definition. Define the Prestress Property as shown below. MnDOT uses the Lump Sum Method to compute losses so both “General P/S Data” and “Loss Data – Lump Sum” tabs are visited.

Note: Bridges built prior to **Oct. 2009** are rated using LFR method. For this method of analysis, MnDOT uses the AASHTO Approximate method to compute losses so the “General P/S Data” tab is the only tab that User will have to visit. For bridges build on or after **Oct. 2009**, Lump Sum Method should be used.

Prestress Properties

Name: 0.6"strands

General P/S Data Loss Data - Lump Sum Loss Data - PCI

P/S strand material: 0.6" (7W-270) LR Jacking stress ratio: 0.750

Loss method: Lump Sum P/S transfer stress ratio:

Transfer time: 24.0 Hours

Age at deck placement: Days

Final age: Days

Loss Data - AASHTO

Percentage DL: 0.0 %

☐ Include elastic gains

OK Apply Cancel

- a. For the Loss Data – Lump Sum tab, enter the Final loss and Composite loss values from the beam detail section of the bridge plan. See image below. Click OK to save to memory and close the window.

Prestress Properties

Name: 0.6"strands

General P/S Data Loss Data - Lump Sum Loss Data - PCI

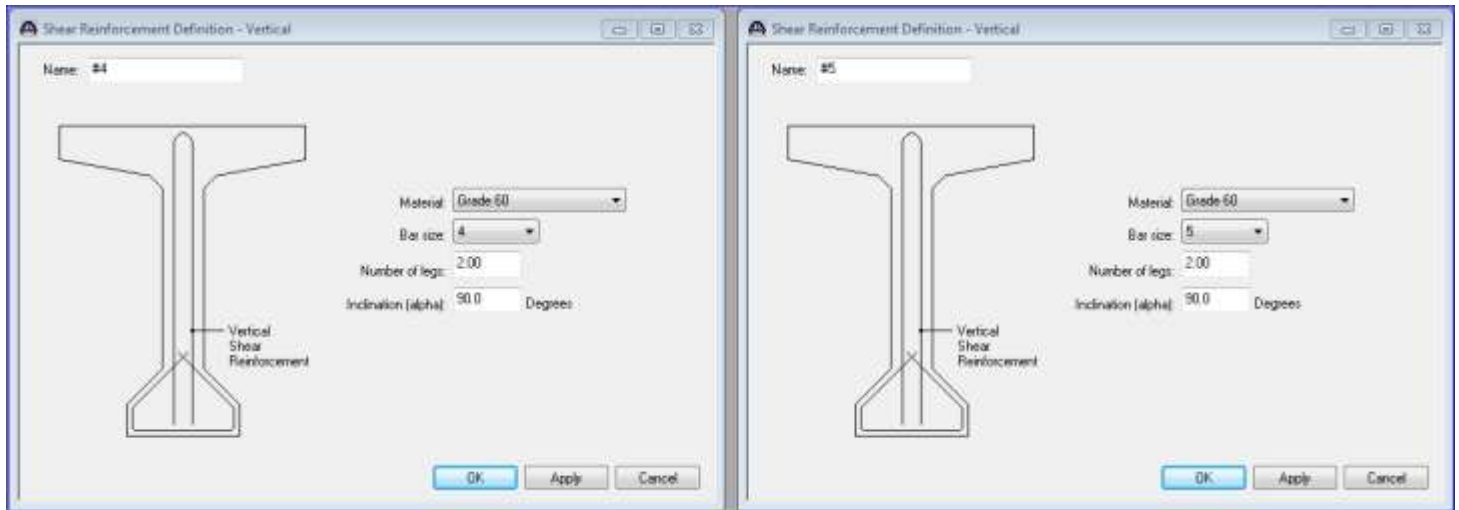
Final loss: 45.400 ksi Final Loss = Total Losses (from beam sheet detail)

Composite loss: 22.400 ksi Composite loss = Long Term Losses (from beam sheet detail)

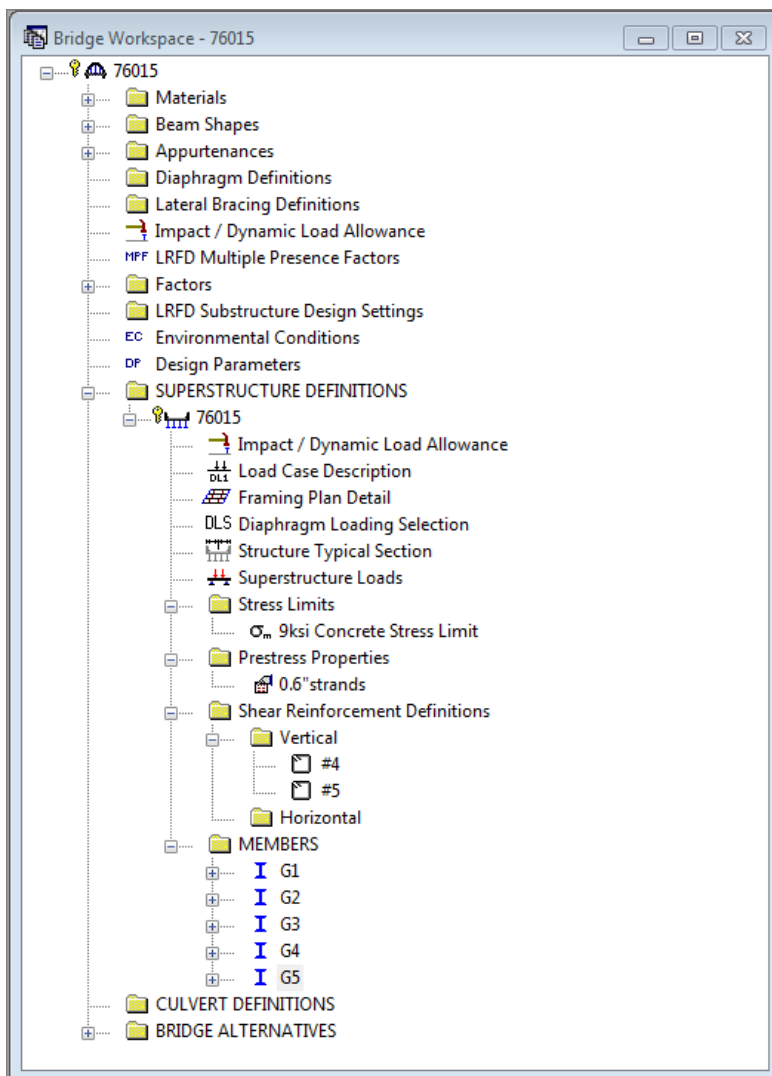
Continuous loss: ksi

OK Apply Cancel

20. Now define the vertical shear reinforcement by double clicking on Vertical (under Shear Reinforcement Definitions in the tree). Define the reinforcements (#4 and #5) as shown below. Click OK to save to memory and close the window.



A partially expanded Bridge Workspace is shown below.



Describing a member: Exterior Beam

21. The G1 member window (see image below) shows the data that was generated when the structure definition was created. No changes are required at this time. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this Member.

Existing	Current	Member Alternative Name	Description
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	exterior	

Span No.	Span Length (ft)
1	82.13

22. Utility load is entered in the Member Loads section under the G1 member in the tree. Double-click Member Loads in the tree to open the window. Under the Uniform tab, select load case that is to be applied, select the span(s) for which the uniform load is to be entered and enter the magnitude of the uniform load as shown below.

MnDOT Design Policy Item:

Note: Unless otherwise confirmed by inspection, include a dead load for utilities of 2 psf of deck area in rural areas and 3 psf in cities and urban areas. Higher loads may be required if heavier utilities are shown on the plan or are known to exist.

Load Case Name	Span	Uniform Load (kip/ft)
Utility	All Spans	0.030

23. As stated earlier (see step 10-a), User has the option of entering Diaphragm load as a concentrated load to act on a member. The Concentrated Tab will allow the User to define the load acting on a member. A sketch is presented illustrating the load type for the selected tab. To show how a User would complete the section, data were entered as shown below. Click OK to save to memory and close the window.

The diagram shows a horizontal girder with a support at the left end. A concentrated load is applied at a distance from the support. The load is represented by a vertical arrow labeled P_y and a horizontal arrow labeled P_x . A moment M is also indicated. A coordinate system is shown at the right end with $+x$ and $+y$ directions.

Pedestrian load: 0.000 lb/ft

Uniform Distributed Concentrated Settlement

Load Case Name	Support Number	Distance (ft)	Px (kip)	Py (kip)	M (kip-ft)
DC1	1	41.06		0.10	

New Duplicate Delete

OK Apply Cancel

Defining a Member Alternative:

24. Expand the G1 member in the tree. Double-click MEMBER ALTERNATIVES in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select Prestressed (Pretensioned) Concrete for the Material Type and PS Precast I for the Girder Type.

New Member Alternative

Material Type:

- Prestressed (Pretensioned) Concrete
- Reinforced Concrete
- Steel
- Timber

Girder Type:

- PS Precast Box
- PS Precast I
- PS Precast Tee
- PS Precast U

OK Cancel

- a. Click OK to close the dialog and create a new member alternative.

25. The Member Alternative Description window will open. Enter the appropriate data as shown below. The Schedule-based Girder property input method is the only input method available for a prestressed concrete beam. To account for the weight of additional stool, residual camber, slope of the deck, super elevation, etc. weight is added in the Self Load section of the Member Alternative Description window as uniform dead load as shown below.

Member Alternative: exterior

Description Specs Factors Engine Import Control Options

Description:

Material Type: Prestressed (Pretensioned)

Girder Type: PS Precast I

Default Units: US Customary

Girder property input method

☒ Schedule based

☐ Cross-section based

Default rating method: LFD

Self Load

Load case: DC1

Additional self load = 0.070 kip/ft

Additional self load = %

Crack control parameter (Z)

Top of beam: kip/in

Bottom of beam: kip/in

Exposure factor

Top of beam:

Bottom of beam:

OK Apply Cancel

Additional Load for difference in Stool Height

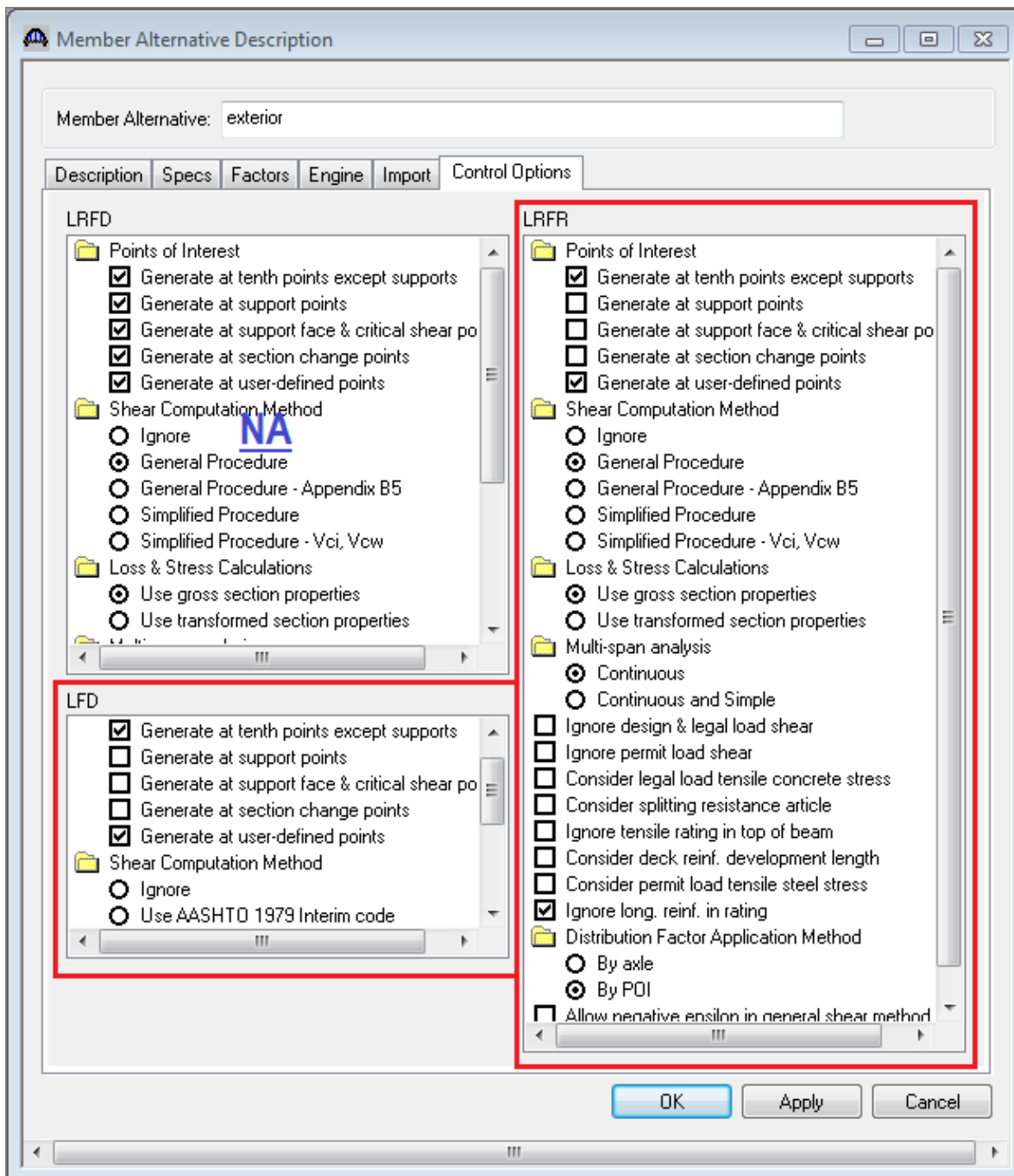
- a. Click on the Control Options Tab. For modeling prestressed concrete beams in BrR, select the following LFD and LRFR control options.

For LFD control options (see image below):

- Points of Interest (POI)
 - Generate at tenth points except supports
 - Generate at user defined points
- Shear Computation Method
 - Use current AASHTO

For LRFR control options (see image below):

- Points of Interest (POI)
 - Generate at tenth points except supports
 - Generate at user-defined points
- Shear Computation Method
 - General Procedure
- Multi-span analysis
 - Continuous
 - Ignore long. reinf. in rating



26. Double-click Live Load Distribution in the tree to compute the distribution factors from typical section.

Standard tab is use for bridges that are Allowable Stress and Load Factor Design. LRFD tab is for bridges that are Load and Resistance Factor Design. If the User tries to use the Compute from Typical Section button on the Standard or LRFD tab to populate the live load distribution factors for this member alternative without creating the rest of adjacent members, you will receive a message that AASHTOWare BrR cannot calculate the distribution factors because beam shapes are not assigned to adjacent member alternatives. This is due to the fact that program does not yet know if we have adjacent prestressed concrete beams. After all members in your superstructure have been created in member alternatives, we can revisit this window to compute the live load distribution factors using the Compute from Typical Section button.

Live Load Distribution

Standard LRFD

Distribution Factor Input Method

☒ Use Simplified Method ☐ Use Advanced Method

☐ Allow distribution factors to be used to compute effects of permit loads with routine traffic

Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane				
Multi-Lane				

Compute from Typical Section... View Calcs

OK Apply Cancel

27. Next is to describe the beam by double clicking on Beam Details in the tree. Enter the required information for the beam as shown below. Beam projection is the distance from the end of the beam to the centerline of bearing.

Span Number	Beam Shape	Girder Material	Prestress Properties	Use Creep	n	Beam Projection	
						Left End (in)	Right End (in)
1	36M	PS 9.0 ksi	0.6" strands	No		7.5000	7.5000

OK Apply Cancel

- a. Click on the next tab, "Stress Limit Ranges", and complete the required information as shown below. Click OK to save to memory and close the window.

Note: Stress Limit Ranges are defined over the entire length of the precast beam, including the projections of the beam past the centerline of bearing which were entered on the Span Detail tab.

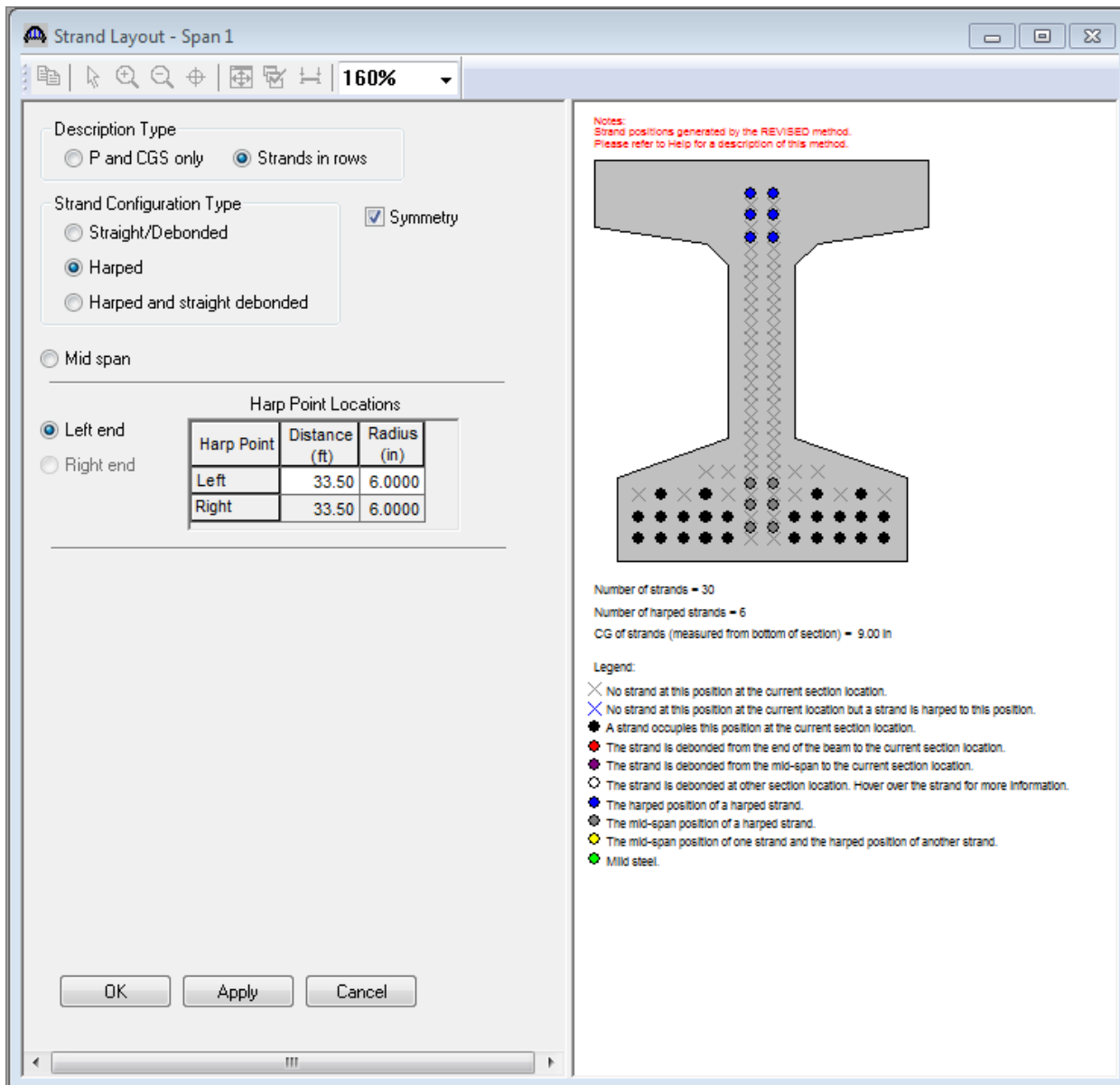
Span Number	Name	Start Distance (ft)	Length (ft)	End Distance (ft)
1	9ksi Concrete Stress Limit	0.00	83.38	83.38

New Duplicate Delete

OK Apply Cancel

28. Expand the tree under Strand Layout and open the Span 1 window. Place the cursor in the schematic view on the right side of the screen. The toolbar buttons in this window will become active. Select the Zoom button to shrink the schematic of the beam shape so that the entire beam is visible.

- Select the Description Type as Strands in rows and the Strand Configuration Type as Harped. The Mid span radio button will now become active. You can now define the strands that are present at the middle of the span by selecting strands in the right hand schematic. Select the bottom 30 strands in the schematic so that the CG of the strands is 3.80 inches.
- Now select the Left end button to enter the following harped strand locations at the left end of the precast beam. Place the cursor in the schematic view on the right side of the screen. You can now define the strands that are present at the left end of the span by selecting strands in the right hand schematic. Select the top, third and fifth row 2 strands in the schematic so that the CG of the strands is 31 inches. Enter Harp Point Locations information. Close the window by clicking OK. This saves the data to memory and closes the window.



29. Double-click Deck Profile in the tree to describe the structural properties of the deck. If the User tries to use the Compute from Typical Section button to describe the deck profile for this member alternative without creating the rest of adjacent members, we will receive a message that AASHTOWare BrR cannot compute from Typical

Section because beam shapes are not assigned to adjacent member alternatives. After all members in your superstructure have been created in member alternatives, we can revisit this window.

MnDOT Design Policy Item:

The topmost 0.5 inch of the wearing course or slab is not considered to be effective for composite action or section properties.


Material	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Structural Thickness (in)	Start Effective Flange Width (Std) (in)	End Effective Flange Width (Std) (in)	Start Effective Flange Width (LRFD) (in)	End Effective Flange Width (LRFD) (in)	n
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30. The haunch profile is defined by double clicking on Haunch Profile in the tree. Enter the required information. The window is shown below.

Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Z1 (in)	Z2 (in)	Z3 (in)	Z4 (in)	Y1 (in)	Y2 (in)	Y3 (in)
1	0.00	82.13	82.13				20.0000	1.5000	1.0000	

31. The Shear Reinforcement Ranges are entered by double clicking on Shear Reinforcement Ranges in the tree. The vertical shear reinforcement is defined as extending into the deck on this tab. This indicates composite action between the beam and the deck. Data does not have to be entered on the Horizontal tab to indicate composite action since we have defined that by extending the vertical bars into deck. Enter the required information and click the OK button. The window is shown below.

PS Shear Reinforcement Ranges



Vertical Horizontal

Span: 1

Name	Extends into Deck	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
#5	<input type="checkbox"/>	0.00	1	2.0000	0.17	0.17
#5	<input checked="" type="checkbox"/>	0.17	3	2.5000	0.63	0.79
#4	<input checked="" type="checkbox"/>	0.79	16	6.0000	8.00	8.79
#4	<input checked="" type="checkbox"/>	8.79	10	12.0000	10.00	18.79
#4	<input checked="" type="checkbox"/>	18.79	17	16.0000	22.67	41.46
#4	<input checked="" type="checkbox"/>	41.46	1	5.5000	0.46	41.92
#4	<input checked="" type="checkbox"/>	41.92	17	16.0000	22.67	64.58
#4	<input checked="" type="checkbox"/>	64.58	10	12.0000	10.00	74.58
#4	<input checked="" type="checkbox"/>	74.58	16	6.0000	8.00	82.58
#5	<input checked="" type="checkbox"/>	82.58	2	2.5000	0.42	83.00
#5	<input type="checkbox"/>	83.00	1	2.5000	0.21	83.21

Stirrup Wizard... New Duplicate Delete

OK Apply Cancel

32. Double-click Points of Interest in the tree to define a point of interest on a beam. Enter points of interest at 0.72h. **Note: For LFR analysis, enter points of interest at h/2.** "h" is the distance from the top of the deck to the bottom of the beam at the centerline of bearing.

$$h = 9\text{in} + 4\text{in} + 36\text{in} = 49\text{in} \qquad 0.72h = 0.72 \left(\frac{49\text{in}}{12\frac{\text{in}}{\text{ft}}} \right) = 2.94\text{ ft}$$

- a. Click Apply and then click OK to save to memory and close the window.

The description of the exterior beam for this structure definition is complete.

Describing a member: Interior Beam

33. The G2 member window (see image below) shows the data that was generated when the structure definition was created. No changes are required at this time. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this Member.

Existing	Current	Member Alternative Name	Description
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	interior	

Span No.	Span Length (ft)
1	82.13

34. Follow steps 21 through 32 to completely define the interior beam (G2).
35. To define the rest of the remaining interior beams and exterior beam, one by one, expand G3, G4 & G5 member in the tree, select from the “Link with” pull down menu to which this member is to be linked as highlighted below. G3 and G4 will be linked with G2 and G5 will be linked with G1. If two members are linked, they share the same definition and any revision to one member affects the other member. If there are any differences between two members, then they should not be linked with one another.

Member name: G3

Description:

Link with: G2

Existing	Current	Member Alternative Name	Description
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	interior	

Number of spans: 1

Span No.	Span Length (ft)
1	82.13

OK Apply Cancel

36. Compute LRFD live load distribution factors for the exterior (G1) and interior girders (G2) by double-clicking Live Load Distribution in the tree. Click on Compute from Typical Section button to calculate LRFD live load distribution factors. Click OK to save to memory and close the window.
37. Define deck properties for the exterior (G1) and interior girders (G2) by double-clicking Deck Profile in the tree. Click on Compute from Typical Section button and enter a slab depth of the full depth minus 0.5 inch as shown below. Click OK twice to save to memory and close the window.

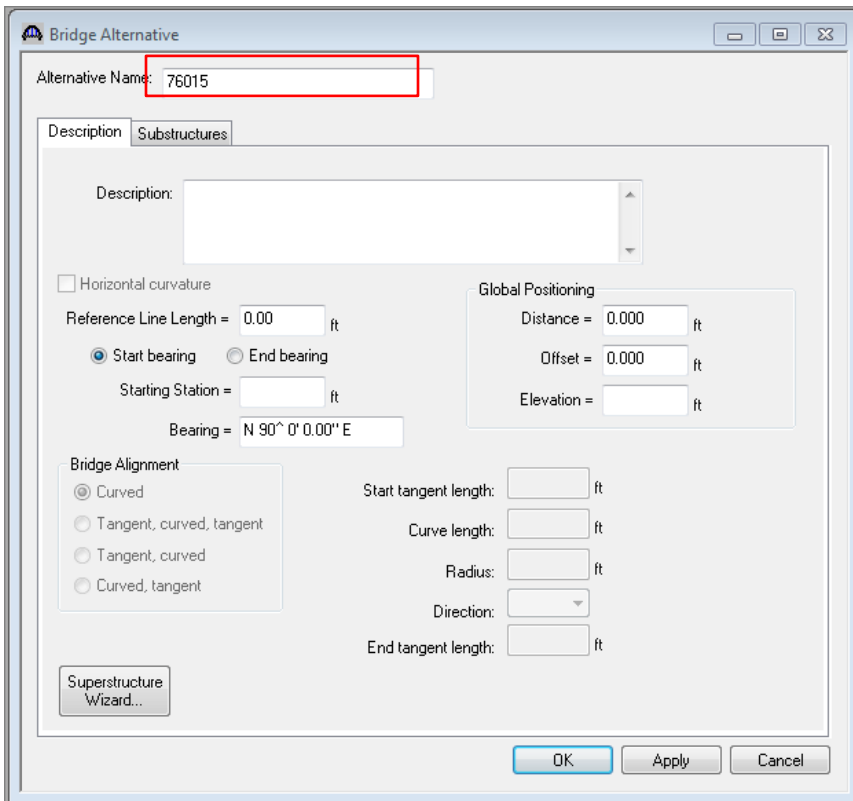
Compute Deck Profile from Structure Typical Section

Total deck thickness entered on the Structure Typical Section window = 9.0000 in

Enter a structural thickness to use when computing the effective flange width: 8.5000 in

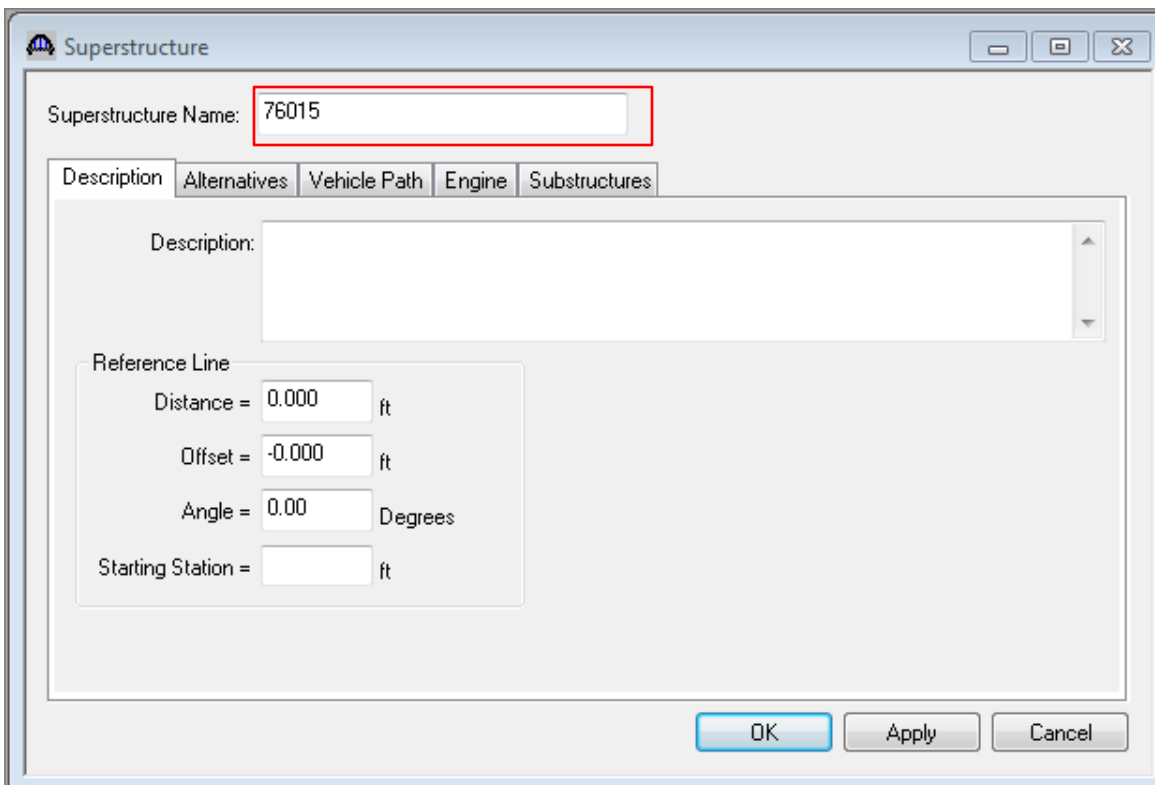
OK Cancel

38. From the bridge workspace, double-click on Bridge Alternatives and enter an Alternative Name as shown below. Click OK to save to memory and close the window.



The 'Bridge Alternative' dialog box is shown. The 'Alternative Name' field is highlighted with a red box and contains the text '76015'. The 'Description' tab is selected. Below the description field, there are several input fields: 'Reference Line Length' (0.00 ft), 'Start bearing' (selected), 'End bearing' (unselected), 'Starting Station' (empty), 'Bearing' (N 90° 0' 0.00" E), 'Global Positioning' (Distance: 0.000 ft, Offset: 0.000 ft, Elevation: empty), 'Bridge Alignment' (Curved selected, Tangent, curved, tangent unselected, Tangent, curved unselected, Curved, tangent unselected), 'Start tangent length' (empty), 'Curve length' (empty), 'Radius' (empty), 'Direction' (empty), and 'End tangent length' (empty). At the bottom, there is a 'Superstructure Wizard...' button and 'OK', 'Apply', and 'Cancel' buttons.

- a. Double-click on superstructure folder in the tree and enter a superstructure name as shown below. Click OK to save to memory and close the window.



The 'Superstructure' dialog box is shown. The 'Superstructure Name' field is highlighted with a red box and contains the text '76015'. The 'Description' tab is selected. Below the description field, there are several input fields: 'Reference Line' (Distance: 0.000 ft, Offset: -0.000 ft, Angle: 0.00 Degrees, Starting Station: empty). At the bottom, there are 'OK', 'Apply', and 'Cancel' buttons.

- b. Double-click on Superstructure Alternatives folder in the tree. Enter a name and select the bridge that was created earlier under the superstructure definitions as shown below. Click OK to save to memory and close the window.

Superstructure Alternative

Alternative Name: 76015

Description:

Superstructure Definition: 76015


Superstructure type: None

Number of main members: 5

Span	Length (ft)
1	82.13

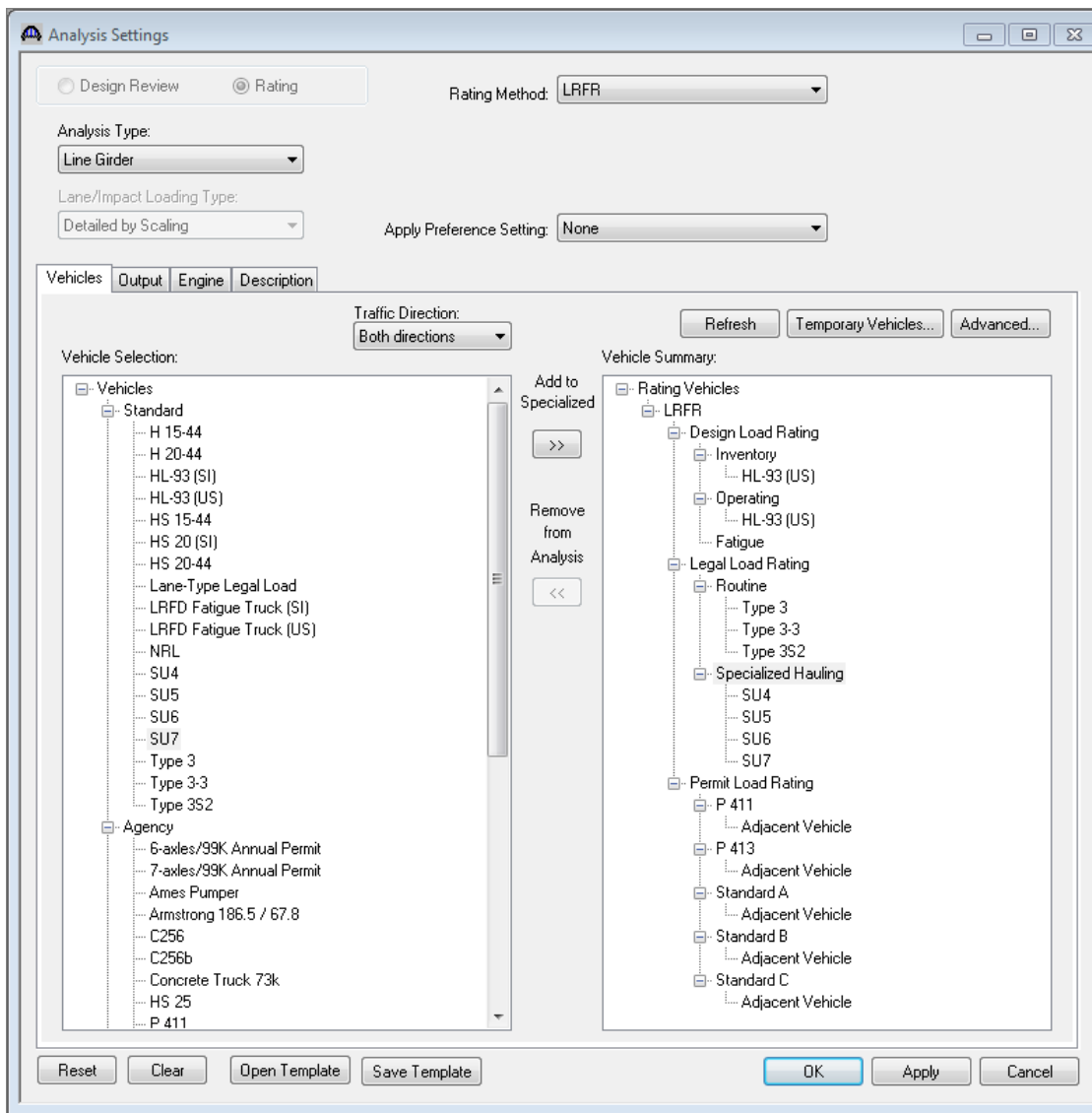
OK Apply Cancel

The AASHTOWare BrR file can now be analyzed.

39. To perform LRFR rating, click the Analysis Settings button, , on the toolbar to open the window shown below. Select the following event setting listed below:

- -Rating Method: LRFR
- -Analysis Type: Line Girder
- -Lane/Impact Loading Type: As Requested
- -Apply Preference Setting: None
- -Traffic Directions: Both Directions

- a. Add vehicles under the Vehicle Summary. To add vehicles under the Vehicle Summary, first select the Inventory under Design Load Rating. Then under Vehicle Selection select the HL-93 (US) vehicle and click on Add to Operating arrow button. Do the same procedure for the Operating under the Design Load Rating. Repeat the same process to add legal loads and permit vehicles to the Vehicle Summary as shown below.



- b. Click on the **Advanced** button in the Analysis Settings window to take you to Vehicle Properties window. This window allows you to override vehicle properties entered in the previous windows. The correct Frequencies and Loading Conditions for the legal and permit vehicles are shown below.
- c. To save the setting, click on the **Save Template** button and enter the desired template name and click **Save**. This Template can be used for future load rating analysis.

Vehicle Properties



Vehicle	Tandem Train	Scale Factor	Impact	Single Lane Loaded	Legal Pair	Override	Legal Live Load Factor	Frequency	Loading Condition	Over
HL-93 (US)	<input type="checkbox"/>	1		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Single Trip	Mixed with traffic	
SU4	<input type="checkbox"/>	1		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Single Trip	Mixed with traffic	
SU5	<input type="checkbox"/>	1		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Single Trip	Mixed with traffic	
SU6	<input type="checkbox"/>	1		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Single Trip	Mixed with traffic	
SU7	<input type="checkbox"/>	1		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Single Trip	Mixed with traffic	
Type 3	<input type="checkbox"/>	1		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Single Trip	Mixed with traffic	
Type 3-3	<input type="checkbox"/>	1		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Single Trip	Mixed with traffic	
P 411	<input type="checkbox"/>	1		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Single Trip	Mixed with traffic	
P 413	<input type="checkbox"/>	1		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Single Trip	Mixed with traffic	
Standard A	<input type="checkbox"/>	1		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Unlimited Crossing	Mixed with traffic	
Standard B	<input type="checkbox"/>	1		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Unlimited Crossing	Mixed with traffic	
Standard C	<input type="checkbox"/>	1		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Unlimited Crossing	Mixed with traffic	

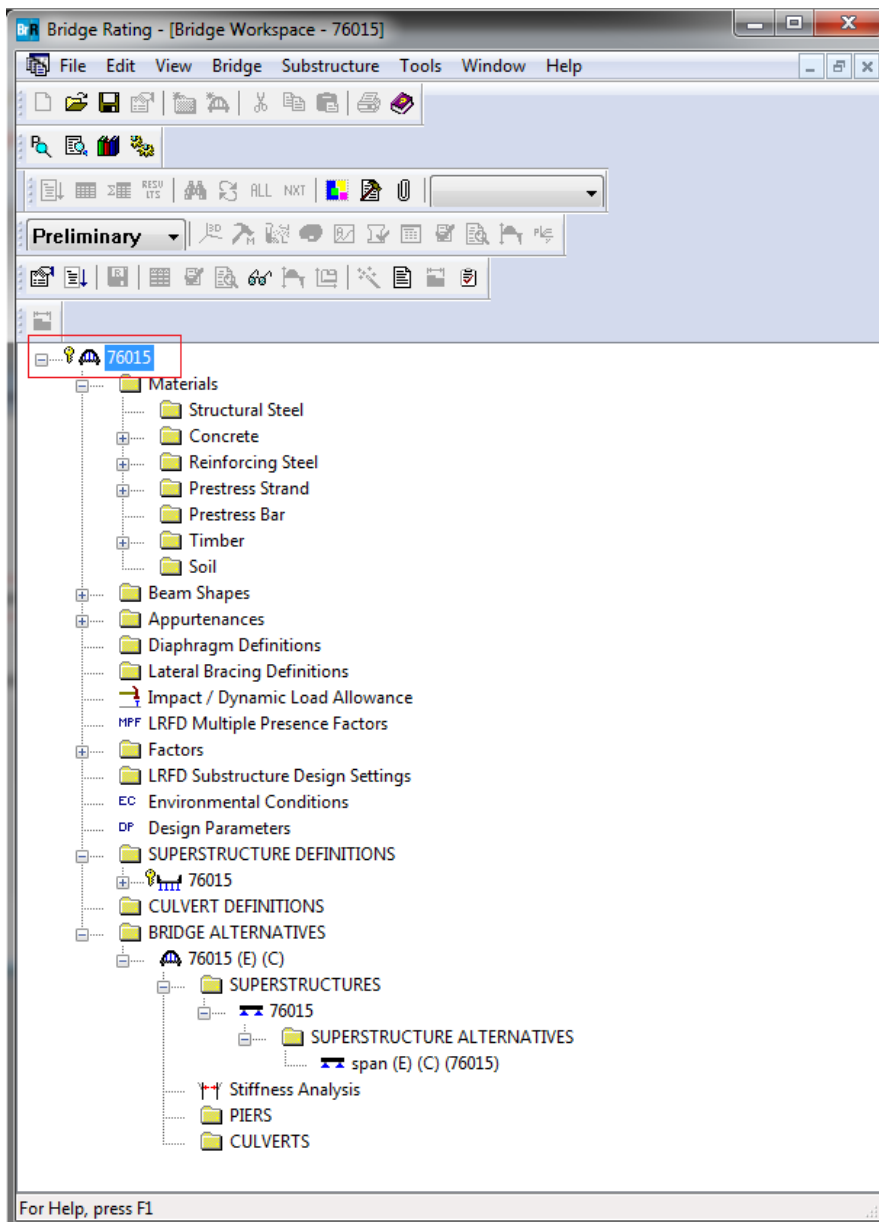
Permit lane load: kip/ft Adjacent vehicle live load factor:

☐ Exclude permit lane load from permit vehicle location

OK
Cancel

d. Click OK to save to memory and close the window.

e. Select the bridge in the Bridge Workspace as shown below and click on the Analyze button,  on the toolbar to perform the rating. When the rating is finished you can review the results by selecting either the exterior girder (G1) or interior girder (G2) under the Member Alternatives folder in the tree and clicking the View analysis Report icon  on the toolbar. The window shown below will open (Load rating results shown are for interior girder only).



Analysis Results - Interior

Report Type

Rating Results Summary

Lane/Impact Loading Type

As Requested

Detailed

Display Format

Multiple rating levels per row

Live Load	Live Load Type	Rating Method	Inventory Load Rating (Ton)	Operating Load Rating (Ton)	Legal Load Rating (Ton)	Permit Load Rating (Ton)	Inventory Rating Factor	Operating Rating Factor	Legal Rating Factor	Permit Rating Factor	Inventory Location Span-(%)	Operating Location Span-(%)	Legal Location Span-(%)	Permit Location Span-(%)	Inventory Limit State	Operating Limit State	Legal Limit State	Permit Limit State
HL-93 (US)	Truck + Lane	LRFR	40.78	64.59	77.16		1.133	1.794			41.06	1-(50.0)	16.43	1-(20.0)	SERVICE-III PS Tensile	STRENGTH-I Concrete Shear		
HL-93 (US)	Tandem + Lane	LRFR	47.32	77.16			1.314	2.143			41.06	1-(50.0)	41.06	1-(50.0)	SERVICE-III PS Tensile	STRENGTH-I Concrete Shear		
Type 3	Axle Load	LRFR			81.50				3.260				16.43	1-(20.0)		STRENGTH-I Concrete Shear		
Type 3-3	Axle Load	LRFR			113.59				2.840				16.43	1-(20.0)		STRENGTH-I Concrete Shear		
Type 3S2	Axle Load	LRFR			100.83				2.801				16.43	1-(20.0)		STRENGTH-I Concrete Shear		
SU4	Axle Load	LRFR			80.13				2.968				16.43	1-(20.0)		STRENGTH-I Concrete Shear		
SU5	Axle Load	LRFR			82.20				2.652				16.43	1-(20.0)		STRENGTH-I Concrete Shear		
SU6	Axle Load	LRFR			85.66				2.473				16.43	1-(20.0)		STRENGTH-I Concrete Shear		
SU7	Axle Load	LRFR			89.93				2.321				41.06	1-(50.0)		STRENGTH-I Concrete Flexure		
Standard A	Axle Load	LRFR			110.36				2.122				16.43	1-(20.0)		STRENGTH-I Concrete Shear		
Standard B	Axle Load	LRFR			120.02				1.765				16.43	1-(20.0)		STRENGTH-I Concrete Shear		
Standard C	Axle Load	LRFR			131.36				1.652				16.43	1-(20.0)		STRENGTH-I Concrete Shear		
P 411	Axle Load	LRFR			277.98				2.686				16.43	1-(20.0)		STRENGTH-I Concrete Shear		
P 413	Axle Load	LRFR			315.95				2.478				16.43	1-(20.0)		STRENGTH-I Concrete Shear		

Controlling Inv. and Oper. Limit State for HL-93

Controlling Inv. and Oper. rating

Legal and Permit Vehicles

Controlling Limit State for Legal and Permit Vehicles

AAASHTO LRFR Engine Version 6.7.1.3001

Analysis Preference Setting: None

Close